**Appendix I:**

As shown in the Methods section, to compute the Lagrangian displacement field from the Eulerian displacement field, we formulate a minimization problem as:

To develop a least squares solution, we rewrite it as:

which can be further rewritten as

where is the Eulerian displacement computed directly from the unwrapped phase of myocardial pixels in frame *f*, and is the computed Lagrangian displacement trajectory field from frame *f-1*. and we assume

It should be noted that the Lagrangian displacement is estimated by solving the minimization problem for each frame independently. The only term related to the previous frame is the estimated Lagrangian displacement vector, . For the first frame we have assumed . Details for computing and are provided in Appendix II.

We solve for by minimizing the energy of the error:

Before solving this problem by least squares, all trajectory field maps (Eulerian and Lagrangian) have to be vectorized. Expanding gives,

Note that each of the four terms in the above equation are scalars and the transpose of a scalar is the same scalar, such that

Using this, we can rewrite as:

Taking the derivative, gives

Setting the derivative to zero, gives

Finally, assuming is invertible, the solution is given by